AMERICAN SOCIETY OF CIVIL ENGINEERS
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TRANSACTIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

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ADDRESS

OF

JAMES BICHENO FRANCIS, President, A. S. C. E.,

At the Thirteenth Annual Convention of the Society, at Montreal, June 15, 1881.

You have assembled in Convention for the first time outside the limits of the United States, and I congratulate you on the selection of this beautiful city, in which, and its immediate neighborhood, there are so many interesting engineering works, constructed with the skill and solidity characteristic of the British school of Engineering. Nine of our members are Canadian Engineers, which must be the excuse of the other members for invading foreign territory.

The Society was organized November 3, 1852, and actively maintained up to March 2, 1855. Eleven only of the present members date from this period. October 2, 1867, the Society was reorganized on a wider basis, and from that time to the present it has been constantly increasing in interest and usefulness.

The membership of the Society is now as follows :

Honorary members	11
Corresponding members	3
Members	491
Associates	21
Juniors	57
Fellows (not including those who are members)	53
Total	636
Subscribers to the Building Fund	99

During the last year we have lost six members by death, and five by resignation, and fifty-six new members have been elected and qualified.

The most interesting event to the society since the last Convention, has been the purchase of a house, in the City of New York, as a permanent home, at a cost of $30 000. This has been accomplished, so far, without taxing the resources of the Society, the required payments having been met by subscription. The sum of $11 900 had been subscribed to the building fund, up to the 25th ultimo, by seventy members and twenty-nine friends of the Society who are not members. The subscription is still open, and it is expected that large additions will be made to it by members and their friends to enable the Society to make the remaining payments without embarrassment.

Meetings of the Society are held twice in each month, during ten months in the year, for the reading and discussion of papers and other purposes ; the new house affords much better accommodations for these purposes than we have ever had before, and also for the library, which now contains 8 850 books and pamphlets, and is constantly increasing. A catalogue of the library is being prepared. Part I., embracing Railroads and the Transactions of Scientific Societies, has been printed and furnished to members.

Water-Power.

Water-power in many of the States is abundant and contributes largely to their prosperity. Its proper development calls for the services of the Civil Engineer, and as it is the branch of the profession with which I am most familiar, I propose to offer a few remarks on the subject.

The earliest applications were to grist and saw mills ; carding and fulling mills soon followed ; these were essential to the comfort of the

early settlers who relied on home industries for shelter, food and clothing, but with the progress of the country came other requirements.

The earliest application of water-power to general manufacturing purposes, appears to have been at Paterson, New Jersey, where "The Society for Establishing Useful Manufactures" was formed in the year 1791. The Passaic River at this point furnishes, when at a minimum, about eleven hundred horse-power, continuously night and day.

The water-power at Lowell, Massachusetts, was begun to be improved for general manufacturing purposes in 1822. The Merrimack River at this point has a fall of thirty-five feet, and furnishes, at a minimum, about ten thousand horse-power during the usual working hours.

At Cohoes, in the State of New York, the Mohawk River has a fall of about one hundred and five feet, which was brought into use, systematically, very soon after that at Lowell, and could furnish about fourteen thousand horse-power during the usual working hours, but the works are so arranged that part of the power is not available at present.

At Manchester, New Hampshire, the present works were commenced in 1835. The Merrimack River at this point has a fall of about fifty-two feet, and furnishes, at a minimum, about ten thousand horse-power, during the usual working hours.

At Lawrence, Massachusetts, the Essex Company built a dam across the Merrimack River, commencing in 1845, and making a fall of about twenty-eight feet, and a minimum power, during the usual working hours, of about ten thousand horse-power.

At Holyoke, Massachusetts, The Hadley Falls Company commenced their works about 1845, for developing the power of the Connecticut River at that point, where there is a fall of about fifty feet, and at a minimum. about seventeen thousand horse-power during the usual working hours.

At Lewiston, Maine, the fall in the Androscoggin River is about fifty feet; its systematic development was commenced about 1845, and with the improvement of the large natural reservoirs at the head waters of the river, now in progress, it is expected that a minimum power, during the usual working hours, of about eleven thousand horse-power will be obtained.

At Birmingham, Connecticut, the Ousatonic Water Company, have developed the water-power of the Housatonic River by a dam giving twenty-two feet fall, furnishing, at a minimum, about two thousand horse-power, during the usual working hours.

The Dundee Water and Land Company, about 1858, developed the power of the Passaic River, at Passaic, New Jersey, where there is a fall of about twenty-two feet, giving a minimum power, during the usual working hours, of about nine hundred horse-power.

The Turner's Falls Company, in 1866, commenced the development of the power of the Connecticut River at Turner's Falls, Massachusetts, by building a dam on the Middle Fall, which is about thirty-five feet, and furnishes a minimum power, during the usual working hours, of about ten thousand horse-power.

I have named the above water-powers as being developed in a systematic manner from their inception, and of which I have been able to obtain some data. In the usual process of developing a large water-power, a company is formed who acquire the title to the property, embracing the land necessary for the site of the town, to accommodate the population which is sure to gather around an improved water-power. The dam and canals or races are constructed, and mill sites with accompanying rights to the use of the water are granted, usually by perpetual leases, subject to annual rents. This method of developing water-power is distinctly an American idea, and the only instance where it has been attempted abroad, that I know of, is at Bellegarde, in France, where there is a fall in the Rhone of about thirty-three feet. Within the last few years works have been constructed for its development, furnishing a large amount of power, but from the great outlay incurred in acquiring the titles to the property, and other difficulties, it has not been a financial success.

The water-powers I have named are but a small fraction of the whole amount existing in the United States and the adjoining Dominion of Canada. There is Niagara, with its two or three millions of horse-power; the St. Lawrence, with its succession of falls from Lake Ontario to Montreal; the Falls of St. Anthony, at Minneapolis, and many other falls, with large volumes of water, on the upper Mississippi and its branches. It would be a long story to name even the large water-powers, and the smaller ones are almost innumerable. In the State of Maine a survey of the water-power has recently been made, the result, as stated in the official report, being "between one and two millions of horse-powers," part of which will probably not be available. There is an elevated region in the northern part of the South Atlantic States, exceeding in area one hundred thousand square miles, in which there is a vast amount

of water-power, and being near the cotton fields, with a fine climate, free from malaria, its only needs are railways, capital and population to become a great manufacturing section.

The design and construction of the works for developing a large water-power, together with the necessary arrangements for utilizing it, and providing for its subdivision among the parties entitled to it, according to their respective rights, affords an extensive field for civil engineers, and, in view of the vast amount of it, yet undeveloped, but which with the increase of population and the constantly increasing demand for mechanical power, as a substitute for hand labor, must come into use, the field must continue to enlarge for a long time to come.

There are many cases in which the power of a water-fall can be made available by means of compressed air, more conveniently than by the ordinary motors. The fall may be too small to be utilized by the ordinary motors; the site where the power is wanted may be too distant from the water-fall, or it may be desired to distribute the power in small amounts at distant points. A method of compressing air by means of a fall of water has been devised by Mr. Joseph P. Frizell, C. E. of St. Paul, Minnesota, which, from the extreme simplicity of the apparatus, promises to find useful applications.* The principle on which it operates is, by carrying the air in small bubbles in a current of water down a vertical shaft to the depth giving the desired compression, then through a horizontal passage, in which the bubbles rise into a reservoir near the top of this passage, the water passing on and rising in another vertical or inclined passage, at the top of which it is discharged, of course, at a lower level than it entered the first shaft. The formation at water-falls is usually rock, which would enable the passages and the reservoir for collecting the compressed air to be formed by simple excavations with no other apparatus than that required to charge the descending column of water with the bubbles of air, which can be done by throwing the water into violent commotion at its entrance, and a pipe and a valve for the delivery of the air from the reservoir.

The transfer of power by electricity is one of the problems now engaging the attention of electricians, and it is now done in Europe in a small way. Sir William Thompson stated, in evidence before an English Parliamentary committee, two years ago, that he looked " forward to the

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* Journal of the Franklin Institute for September, 1877.

"Falls of Niagara being extensively used for the production of light and "mechanical power over a large area of North America," and that a copper wire half an inch in diameter would transmit twenty-one thousand horse-power from Niagara to Montreal, Boston, New York or Philadelphia. His statements appear to have been based on theoretical considerations, but there is no longer any doubt as to the possibility of transferring power in this manner; its practicability for industrial purposes must be determined by trial. Dr. Paget Higgs, a distinguished English electrician, is now experimenting on it in the City of New York.

Great improvements in reaction water-wheels have been made in the United States within the last forty years. In the year 1844 the late Uriah Atherton Boyden, a civil engineer of Massachusetts, commenced the design and construction of Fourneyron turbines, in which he introduced various improvements and a general perfection of form and workmanship, which enabled a larger percentage of the theoretical power of the water to be utilized than had been previously attained. The great results obtained by Boyden with water-wheels, made in his perfect manner, and, in some instances, almost regardless of cost, undoubtedly stimulated others to attempt to approximate to these results at less cost, and there are now many forms of wheel of low cost, giving fully double the power, with the same consumption of water, that was obtained from most of the older forms of wheels of the same class.

Anchor Ice.

A frequent inconvenience in the use of water-power in cold climates is that peculiar form of ice called anchor or ground ice. It adheres to stones, gravel, wood and other substances forming the beds of streams, the channels of conduits and orifices through which water is drawn; sometimes raising the level of water courses many feet by its accumulation on the bed, and entirely closing small orifices through which water is drawn for industrial purposes. I have been for many years in a position to observe its effects, and the conditions under which it is formed.

The essential conditions are, that the temperature of the water be at its freezing point, and that of the air below that point; the surface of the water must be exposed to the air and there must be a current in the water.

The ice is formed in small needles on the surface, which would remain there and form a sheet if the surface was not too much agitated,

except for a current or movement in the body of water sufficient to maintain it in a constant state of intermixture. Even when flowing in a regular channel, there is a continual interchange of position of the different parts of a stream; the retardation of the bed causes variations in the velocity which produce whirls and eddies, and a general instability in the movement of the water in different parts of the section. The result being that the water at the bottom soon finds its way to the surface, and the reverse. I found by experiments on straight canals, in earth and masonry, that colored water discharged at the bottom reached the surface at distances varying from ten to thirty times the depth.* In natural water courses, in which the beds are always more or less irregular, the disturbance would be much greater. The result is, that the water at the surface of a running stream does not remain there, and when it leaves the surface it carries with it the needles of ice, the specific gravity of which differs but little from that of the water, which, combined with their small size, allows them to be carried by the currents of water in any direction. The converse effect takes place in muddy streams. The mud is apparently held in suspension, but is only prevented from subsiding by the constant intermixture of the different parts of the stream; when the current ceases, the mud sinks to the bottom, the earthy particles composing it being heavier than water, would sink in still water in times inversely proportional to their size and specific gravity. This, I think, is a satisfactory explanation of the manner in which the ice formed at the surface finds its way to the bottom; its adherence to the bottom, I think, is explained by the phenomenon of *regelation*, first observed by Faraday; he found that when the wetted surfaces of two pieces of ice were pressed together they froze together, and that this took place under water, even when above the freezing point. Professor James D. Forbes found that the same thing occurred by mere contact, without pressure, and that ice would become attached to other substances in a similar manner. Regelation was observed by these philosophers in carefully arranged experiments with prepared surfaces, fitting together accurately, and kept in contact sufficiently long to allow the freezing together to take place. In nature these favorable conditions would seldom occur in the masses of ice commonly observed, but we must admit, on the evidence of the recorded experiments, that, under

* Paper CLX. in the Transactions of the Society, 1878, vol. VII., pages 109, 168.

particular circumstances, pieces of ice will freeze together or adhere to other substances in situations where there can be no abstraction of heat.

When a piece of ice of considerable size comes in contact under water, with ice or other substance, it would usually touch in an area very small in proportion to its mass, and other forces acting upon it, and tending to move it, would usually exceed the freezing force, and regelation would not take place. In the minute needles formed at the surface of the water, the tendency to adhere would be much the same as in larger masses touching at points only, while the external forces acting upon them would be extremely small in proportion, and regelation would often occur, and of the immense number of the needles of ice formed at the surface, enough would adhere to produce the effect which we observe and call anchor ice. The adherence of the ice to the bed of the stream or other objects, is always down stream from the place where they are formed; in large streams it is frequently many miles below; a large part of them do not become fixed, but, as they come in contact with each other, regelate and form spongy masses, often of considerable size, which drift along with the current, and are often troublesome impediments to the use of water-power.

Water-powers supplied directly from ponds or rivers, or canals frozen over for a long distance immediately above the places from which the water is drawn, are not usually troubled with anchor ice, which, as I have stated, requires open water, up stream, for its formation.